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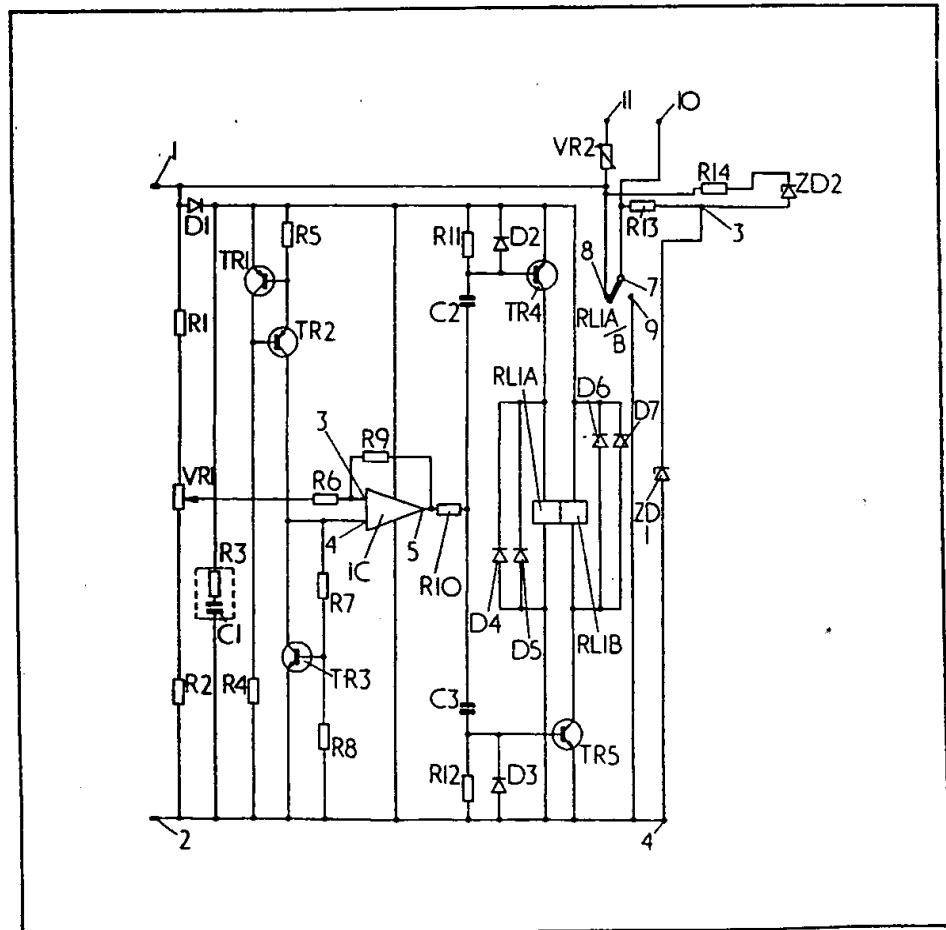
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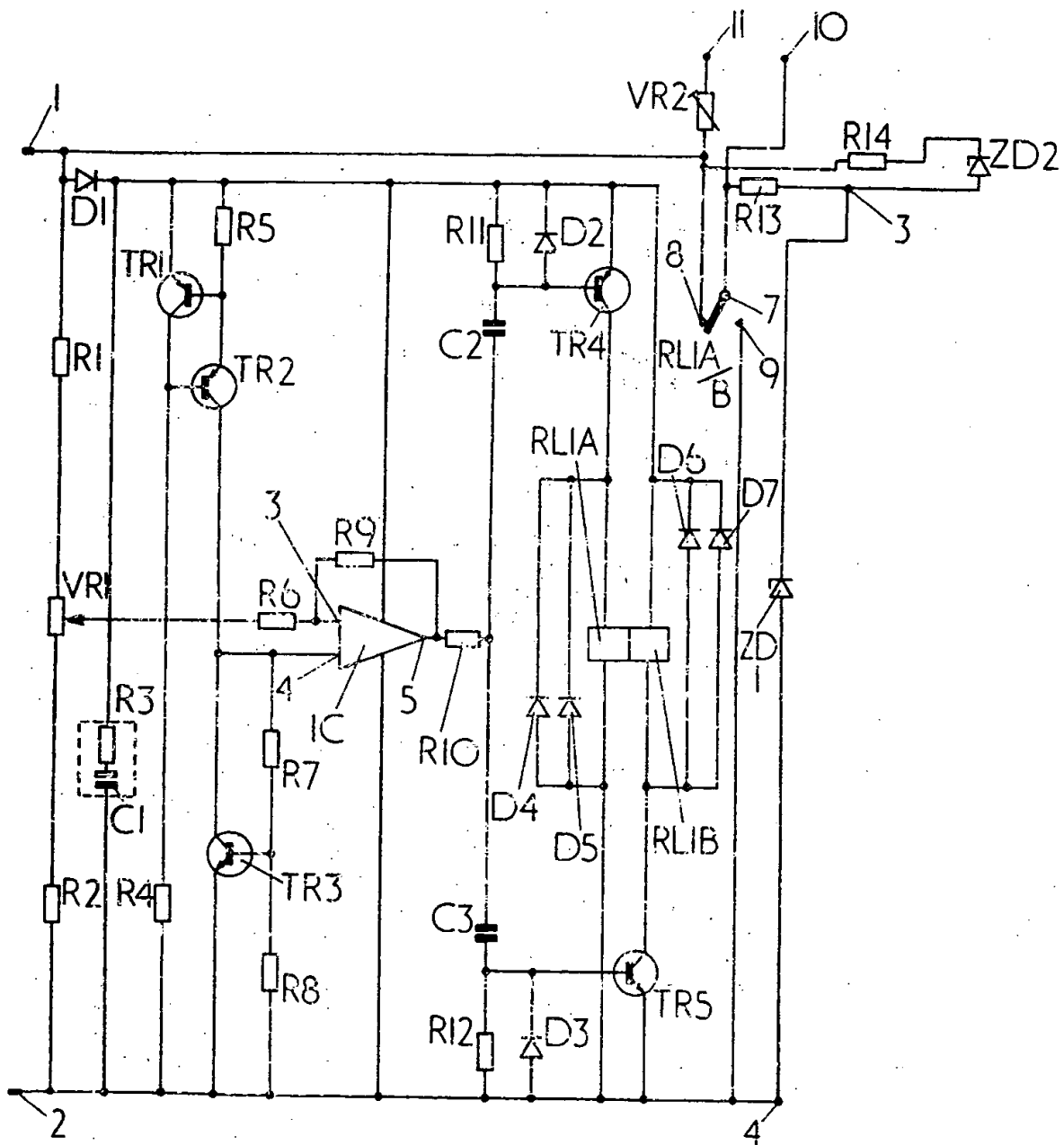
(54) Protection circuit

(57) The input to the circuit from a battery is sampled and a voltage fed 2 to a comparator IC for comparison with a reference voltage 3. The output 5 operates a bistable relay RL1A/B to one of its two states. When the input voltage falls below the reference voltage current is derived from a storage circuit R3, C1 to operate the relay.



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## SPECIFICATION

## Protection circuit

- 5 This invention relates to a protection circuit and finds particular, although not exclusive, application in explosive environments such as mines and petroleum refineries where an intrinsically safe standard of electrical operation has to be applied.
- 10 The circuit of the invention is concerned with ensuring that electrical circuitry with which it is associated does not give false or spurious readings due to a leak of, or falling off of, power from a d.c. source.
- 15 The circuit may typically be used in conjunction with measuring and indicating circuitry and apparatus. A measuring instrument typically comprises a sensor which is affected by changes in a parameter to be measured by the instrument. The
- 20 sensor derives an electrical output signal of value related to the changes in the parameter. The electrical signal may then be used to drive a meter and operate a recording apparatus including a storage medium for example a tape or a pressure sensitive
- 25 graphic recorder.
- In many applications, such as in a coal mine, it is necessary to measure more than one parameter relating to environment such as temperature and humidity.
- 30 Where more instruments are run from a battery it is often necessary to ensure that they, and their associated circuitry, are designed to have as low a current consumption as possible in order to enable the instruments to be left remotely to record for long
- 35 periods. However, if the battery of d.c. source becomes faulty and gives a low output the readings obtained by the instruments may be substantially wrong and thus misleading to a scientist who has to interpret them. Thus it is better for the instruments
- 40 to be rendered inoperative in the event of a power source fall off rather than to give inaccurate information. In this way the scientist reading the result readily appreciates a fault condition exists in the instrument rather than the parameters being monitored
- 45 have changed drastically.
- Previously it has been easy to prevent against over voltage being supplied to operating circuits by the use of zener diodes, over-voltage relays and over-voltage circuitry. The detection of under voltage
- 50 conditions has not been so easy and has required relays which require substantial power consumption to hold them in.
- It is an object of the present invention to provide a protection circuit to monitor and react to a fall off or
- 55 cessation of a d.c. power source which is not itself highly consumptive of power and thus a drain on the source but which is capable of switching the circuit to an off condition even after the failure of the d.c. power source.
- 60 According to the present invention a protection circuit including a source of constant current, a comparator, a switching arrangement and a current stor-

age circuit in which, in use, the source of constant current is connected to one input of the comparator to provide a reference voltage thereto, whilst a sample voltage related to the input voltage of the protection circuit is fed to a second input of the comparator, the comparator having its output connected to the switching arrangement and being arranged to

65 hold the arrangement in a first condition to give an output from the circuit when the sampled voltage has a value above that of the reference voltage and to cause it to change to a second condition to prohibit an output from the circuit when the sampled

70 voltage falls below that of the reference voltage, the energy for the change of the switching arrangement from its first to its second condition being obtained from the current storage circuit.

Preferably the current storage circuit comprises a

80 capacitor and a series resistor connected across the input to the protection circuit. The comparator may have its output fed back to its sample voltage input through a resistor to provide hysteresis for the comparator.

85 A zener diode with a series resistor may be connected to give a load to the d.c. power source when the switching arrangement changes to its second condition. The switching arrangement may include a bistable relay controlled through a transistor switching

90 arrangement, and the sample voltage may be derived from a variable resistor connected across the power supply input to the circuit.

In order that the invention may be readily understood one example of a protection circuit in accordance therewith will now be described with reference to the accompanying drawing.

Referring now to the drawing, the circuit has input terminals 1, 2 for connection respectively to the positive and negative terminals of a d.c. power source,

100 and output terminals 3, 4 for connection to other circuitry, for example that of a combined humidity and temperature sensor and recorder.

Two fixed value resistors R1, R2 are connected in series with a variable resistor VR1 across the input terminals 1, 2. A parallel arrangement comprising a

105 resistor R3 and a series capacitor C1 which constitute a trip voltage store are also connected to terminals 1 and 2.

A solid state integrated circuit comparator 1C is provided which has two input terminals 3, 4 and an

110 output terminal 5. The terminal 5 is connected back to the non-inverting terminal 3 via a resistor R9 to give a degree of hysteresis to the comparator and thus avoid any 'chatter' of operation. The input terminal 3 of comparator 1C is also connected to the wiper of the variable resistor VR1 through a resistor R6. The terminal 4 of comparator 1C receives a reference voltage input. This is derived from a reference voltage source comprising resistors R7, R8 and

115 transistor TR3. The transistor TR3 is fed from a constant current sub-circuit comprised of transistors TR1, TR2 and resistor R5. Resistor R4 connects this sub-circuit to the negative side of the input.

The output 5 of comparator 1C is connected to a

switching arrangement comprising a bistable relay RL1A, RL1B controlled by NPN switching transistor TR4 and PNP switching transistor TR5 respectively. Transistor TR4 has associated with it resistor R11, capacitor C2 and diode D2, while transistor TR5 has resistor R12, capacitor C3 and diode D3. Further diodes D4, D5 and D6 D7 are used to shunt back e.m.f generated by the relay coils RL1A RL1B respectively. A change over contact operated by the relay connects a central contact 7 to either a fixed contact 8 associated with RL1A or a fixed contact 9 associated with RL1B. Contact 7 is connected to output terminal 3 through a resistor R13 and also to test terminal 10. Contact 8 is connected to positive supply terminal 1 and to test terminal 11 via a variable resistor VR2. Contact 9 is connected directly to the negative supply terminal 2.

A Zener diode ZD1 connected across the output terminals 3, 4, prevents the voltage being supplied to the processing circuit exceeding 15 volts. This is necessary because although the battery is a nominal 12 volts a float charged battery can rise to 16.4 volts and excess voltage would damage the circuitry connected to output terminals 3, 4. A further zener diode ZD2 is provided in series with a resistor R14 for maintaining a load on the battery following shut down, and thus preventing battery recovery from repeatedly tripping the switching circuit.

In operation the protection circuit of the invention ensures that the voltage supplied to the output terminals 3, 4 cannot fall to a level which would cause malfunctioning of the circuitry connected to them. This is done by sampling the supply voltage from the resistor VR1 which is fed to terminal 3 of comparator IC and comparing this sample voltage with the reference voltage fed to terminal 4.

When the supply sampled voltage is greater than the reference voltage, the output from the comparator IC is in a high logic state and thus TR5 has been pulsed on for the time constant formed by the capacitor C3 and resistors R10 and R12. The resultant TR5 collector pulse causes the relay RL1B to latch to the state shown in the Figure in which contacts 7 and 8 are connected and power is supplied to the output terminals 3, 4.

However, if the battery becomes discharged, then the sampled voltage from the variable resistor VR1 will fall below the reference voltage on input 4 of comparator IC. Consequently, the output of the comparator IC at terminal 5 goes low, allowing base current to flow in the NPN transistor TR4 for a period determined by the value of the capacitor C2 and resistors R10 and R11. The resultant TR4 collector pulse momentarily energises relay RL1A and thus latches the contacts 7 and 9 to cut off the power supply to the output terminals and protect the attached circuitry from external noise spikes on the rail. When contacts 7 and 9 are connected the series combination of zener diode ZD2 and its ballast resistor R23 ensure that a load is maintained on the battery, so that should the supply voltage rise above a nominal ten volts, a further battery voltage rise due to a no load condition is avoided, and thus the circuit will not oscillate between the two states.

As so far described, the circuitry would not pre-

vent faulty operation under all circumstances. If, for example, a battery having sufficiently high output voltage to ensure reliable operation were replaced with a flat battery having a very low voltage output, relays RL1A/B could not be operated owing to the absence of sufficient power.

To overcome this difficulty the trip store comprising capacitor C1 (1000  $\mu$ F) having its own current limiting resistor R3 is connected across the supply.

The battery supply on switch-on causes the capacitor C1 to be charged to the nominal supply voltage less the voltage drop across diode D1. Should the battery then be removed, the capacitor C1 will hold up the voltage sufficiently long to operate the comparator IC and thus cause relay RL1A to be pulsed. In this way, the insertion of a faulty battery will not enable erroneous results to arise as sufficient power is not supplied to the circuitry to cause the relay RL1B to operate.

The comparator IC1 has a positive feedback to ensure hysteresis about the nominal operating point in order to prevent RL1A/B chattering should the falling battery level recover upon removal of the main load.

The circuit described consumes very little power and is suitable for use with intrinsically safe designed circuits, such as those used in mines.

#### CLAIMS

1. A protection circuit including a source of constant current, a comparator, a switching arrangement and a current storage circuit, in which, in use, the source of constant current is connected to one input of the comparator to provide a reference voltage thereto, whilst a sample voltage related to the input voltage of the protection circuit is fed to a second input of the comparator, the comparator having its output connected to the switching arrangement and being arranged to hold the arrangement in a first condition to give an output from the circuit when the sampled voltage has a value above that of the reference voltage and to cause it to change to a second condition to prohibit an output from the circuit when the sampled voltage falls below that of the reference voltage, the energy for the change of the switching arrangement from its first to its second condition being obtained from the current storage circuit.

2. A protection circuit as claimed in Claim 1 in which the current storage circuit comprises a capacitor and a series resistor connected across the input to the protection circuit.

3. A protection circuit as claimed in Claim 1 or Claim 2 in which the comparator output is fed back to the sampled voltage input through a resistor to give hysteresis to the comparator.

4. A protection circuit as claimed in any preceding claim and including a Zener diode in series with a resistor arranged to provide a load on the d.c. source when the switching arrangement switches to its said second condition.

5. A protection circuit as claimed in any preceding claim in which the switching arrangement includes a bistable relay controlled through a transistor switching arrangement.

6. A protection circuit as claimed in any preceding claim in which the sample voltage is derived

from a variable resistor connected across the power supply input to the circuit.

7. A protection circuit substantially as hereinbefore described with reference to the accompanying drawing.

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